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Kie Y. Ahn

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EXAMINER

LE, THAO X

ART UNIT

PAPER NUMBER

2814

DATE MAILED: 02/26/2002

Please find below and/or attached an Office communication concerning this application or proceeding.

Office Action Summary

Application No.

09/881,408

Applicant(s)

AHN ET AL.

Examiner

Thao X Le

Art Unit

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-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133).
- Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

- 1) ☐ Responsive to communication(s) filed on ____.
- 2a) ☐ This action is **FINAL**. 2b) ☒ This action is non-final.
- 3) ☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

- 4) ☒ Claim(s) 1-51 is/are pending in the application.
- 4a) Of the above claim(s) 32-51 is/are withdrawn from consideration.
- 5) ☐ Claim(s) ____ is/are allowed.
- 6) ☒ Claim(s) 1-31 is/are rejected.
- 7) ☐ Claim(s) ____ is/are objected to.
- 8) ☒ Claim(s) 1-51 are subject to restriction and/or election requirement.

Application Papers

- 9) ☐ The specification is objected to by the Examiner.
- 10) ☐ The drawing(s) filed on ____ is/are: a) ☐ accepted or b) ☐ objected to by the Examiner.
- Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).
- 11) ☐ The proposed drawing correction filed on ____ is: a) ☐ approved b) ☐ disapproved by the Examiner.
- If approved, corrected drawings are required in reply to this Office action.
- 12) ☐ The oath or declaration is objected to by the Examiner.

Priority under 35 U.S.C. §§ 119 and 120

- 13) ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
- a) ☐ All b) ☐ Some * c) ☐ None of:
- ☐ Certified copies of the priority documents have been received.
 - ☐ Certified copies of the priority documents have been received in Application No. ____.
 - ☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).
- * See the attached detailed Office action for a list of the certified copies not received.
- 14) ☐ Acknowledgment is made of a claim for domestic priority under 35 U.S.C. § 119(e) (to a provisional application).
- a) ☐ The translation of the foreign language provisional application has been received.
- 15) ☐ Acknowledgment is made of a claim for domestic priority under 35 U.S.C. §§ 120 and/or 121.

Attachment(s)

- 1) ☒ Notice of References Cited (PTO-892)
- 2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
- 3) ☒ Information Disclosure Statement(s) (PTO-1449) Paper No(s) 4.
- 4) ☐ Interview Summary (PTO-413) Paper No(s) ____.
- 5) ☐ Notice of Informal Patent Application (PTO-152)
- 6) ☐ Other:

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DETAILED ACTION

Election/Restrictions

1. Restriction to one of the following inventions is required under 35 U.S.C. 121:

Group I: Claims 1-38, drawn to a semiconductor process, classified in class 438, subclass 722+.

Group II: Claim 39-51, drawn to a semiconductor device, classified in class 257, subclass 288+, 300+ or 296+

2. Inventions II and I are related as process of making and product made. The inventions are distinct if either or both of the following can be shown: (1) that the process as claimed can be used to make other and materially different product or (2) that the product as claimed can be made by another and materially different process (MPEP § 806.05(f)). In the instant case, the product as claimed can be made by another and materially different process. For example, in claim 1, the dielectric layer (silicon dioxide) can be formed first over the surface, and then forming the first and second metal-containing dielectric layers over silicon dioxide layer.

3. Because these invention are distinct for the reason given above and have acquired a separate status in the art as shown by their different classifications, restriction for examination purpose as indicated is proper.

4. This application contains claims directed to the following patentably distinct species of the claimed invention:

In the event that invention I is elected, the following election of species is required:

(a) A method for forming a dielectric layer and a MOS transistor in claims 1-31.

(b) A method for forming a capacitor structure in claims 32-38.

Applicant is required under 35 U.S.C. 121 to elect a single disclosed species for prosecution on the merits to which the claims shall be restricted if no generic claim is finally held to be allowable. Currently, there is no generic.

Applicant is advised that a reply to this requirement must include an identification of the species that is elected consonant with this requirement, and a listing of all claims readable thereon, including any claims subsequently added. An argument that a claim is allowable or that all claims are generic is considered nonresponsive unless accompanied by an election.

Upon the allowance of a generic claim, applicant will be entitled to consideration of claims to additional species which are written in dependent form or otherwise include all the limitations of an allowed generic claim as provided by 37 CFR 1.141. If claims are added after the election, applicant must indicate which are readable upon the elected species. MPEP § 809.02(a).

Should applicant traverse on the ground that the species are not patentably distinct, applicant should submit evidence or identify such evidence now of record showing the species to be obvious variants or clearly admit on the record that this is the case. In either instance, if the examiner finds one of the inventions unpatentable over the prior art, the evidence or admission may be used in a rejection under 35 U.S.C. 103(a) of the other invention.

5. During a telephone conversation with Applicant's Attorney, Mr. Dave Latwesen, on 07 Feb. 2002 and on 20 Feb. 2002 a provisional election was made without traverse to prosecute the invention of Dielectric layer forming method and devices formed therewith, (species (a), claims 1-31). Affirmation of this election must be made by applicant in replying to this Office action.

Claim 32-51 are withdrawn from further consideration by the examiner, 37 CFR 1.142(b), as being drawn to a non-elected invention.

6. Applicant is advised that the response to this requirement to be complete must include an election of the invention to be examined even though the requirement be traversed (37 CFR 1.143).

7. Applicant is reminded that upon the cancellation of claims to a non-elected invention, the inventorship must be amended in compliance with 37 CFR 1.48(b) if one or more of the currently named inventors is no longer an inventor of at least one claim remaining in the application. Any amendment of inventorship must be accompanied by a request under 37 CFR 1.48(b) and by the fee required under 37 CFR 1.17(i).

Drawings Objection

8. The drawings are objected to as failing to comply with 37 CFR 1.84(p)(5) because they include the following reference sign(s) not mentioned in the description: 80 in fig. 3 and 35 in fig. 4. A proposed drawing correction, corrected drawings, or amendment to the specification to add the reference sign(s) in the description, are required in reply to the Office action to avoid abandonment of the application. The objection to the drawings will not be held in abeyance.

Claim Rejections - 35 USC § 102

9. The following is a quotation of the appropriate paragraphs of 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

A person shall be entitled to a patent unless –

(b) the invention was patented or described in a printed publication in this or a foreign country or in public use or on sale in this country, more than one year prior to the date of application for patent in the United States.

10. Claims 1-4 are rejected under 35 U.S.C. 102(e) as being anticipated by Pub. No.: U.S. 2001/0013629 to Bai.

Regarding to claim 1, Bai reference teaches a method of forming a dielectric layer comprising: a substrate 105 comprising a silicon-containing surface, forming a first metal-containing dielectric layer 130 over the surface, the metal comprising an element selected from group IVB of the periodic table, forming a second metal-containing dielectric layer 120 over the first metal-containing dielectric layer. See fig.1

Regarding to claims 2, Bai teaches the first metal-containing dielectric layer 130 comprises hafnium, paragraph [0018].

Regarding to claim 3-4, Bai discloses a method further comprising: forming a layer of silicon dioxide, t_{ox} , claim 4, overlying at least one portion of the surface, and forming the first metal-containing dielectric layer 130 comprises forming a metal layer over the layer of silicon dioxide, and combining metal of the metal layer with oxygen of the silicon dioxide to form a metal oxide dielectric material, and the metal layer comprises hafnium, paragraph [0018].

11. Claims 1-4, 6-8, 19 are rejected under 35 U.S.C. 102(e) as being anticipated by Pub. No.: U.S. 2001/0013629 to Bai.

Regarding to claim 1, Bai reference teaches a method of forming a dielectric layer comprising: a substrate 105 comprising a silicon-containing surface, forming a first metal-containing dielectric layer 130 over the surface, the metal comprising an element selected from group IVB of the periodic table, forming a second metal-containing dielectric layer (the second metal-containing dielectric layer as claimed corresponding to

“a third dielectric layer” as discloses in claim 7 and paragraph [0027]) over the first metal-containing dielectric layer. See fig. 1

Regarding to claims 2, Bai teaches the first metal-containing dielectric layer 130 comprises hafnium, paragraph [0018].

Regarding to claim 3-4, Roberts discloses a method further comprising: forming a layer of silicon dioxide, t_{ox} , claim 4, overlying at least one portion of the surface, and forming the first metal-containing dielectric layer 130 comprises forming a metal layer over the layer of silicon dioxide, and combining metal of the metal layer with oxygen of the silicon dioxide to form a metal oxide dielectric material, and the metal layer comprises hafnium, paragraph [0018].

Regarding to claim 6, 7, Bai teaches the second metal-containing dielectric layer comprises an element selected from group IIIB of the periodic table, where the second metal-containing dielectric layer comprises lanthanum, paragraph [0027]

Regarding to claim 8, Bai's reference teaches: forming the first metal-containing dielectric layer and the second metal-containing dielectric layer comprise: forming a hafnium-containing layer, forming a lanthanum-containing layer over the hafnium-containing layer, and exposing the hafnium-containing layer and the lanthanum-containing layer to an oxygen comprising atmosphere and heating the hafnium-containing layer and the lanthanum-containing layer to a temperature effective to form a hafnium-containing dielectric layer and a lanthanum-containing dielectric layer, paragraph [0018].

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Regarding to claim 19, Bai teaches the first metal-containing dielectric layer consist of hafnium oxide and the second metal-containing dielectric layer consist of lanthanum oxide, paragraph [0018] and [0027].

12. Claim 20, 23-25, 30-31 are rejected under 35 U.S.C. 102(e) as being anticipated by Pub. No.: 2001/0013629 to Bai.

Regarding to claim 20, Bai reference teaches a method for forming a MOS transistor, comprising: providing a semiconductor substrate 105 having a surface comprising silicon, forming a hafnium-containing dielectric layer 130 overlying the surface, forming a lanthanum-containing, claim 7 and paragraph [0027], and forming a gate electrode 110 over the hafnium-containing dielectric layers, see fig. 1.

Regarding to claim 23, Bai teaches a method further comprising forming a layer of silicon dioxide, t_{ox} , see claim 4, over at least a portion of the surface comprising silicon prior to the forming of the hafnium-containing dielectric layer.

Regarding to claim 24-25, Bai teaches forming of the hafnium-containing dielectric layer and the lanthanum-containing dielectric layer comprises first forming a hafnium-containing layer and second forming a lanthanum-containing layer over the substrate, see fig. 1 and paragraph [0027], and exposing the hafnium and lanthanum containing layer to an oxygen comprising atmosphere while heating the hafnium and the lanthanum layers to a temperature effective to form a hafnium-containing dielectric layer and a lanthanum-containing dielectric layer, where forming a hafnium-containing dielectric layer and a lanthanum-containing dielectric layer comprise forming oxides of hafnium and lanthanum, respectively, paragraph [0018].

Regarding to claim 30, Bai discloses the thickness of the hafnium-containing layer, t_1 in table 1, is no greater than about 1 nm.

Regarding to claim 31, Bai teaches the hafnium-containing dielectric layer 130 and the lanthanum-containing layer (third dielectric layer, paragraph [0027]), where the gate dielectric layer, t_{ox} , is form having an equivalent oxide thickness less than or equal to 2nm, see table 1.

Claim Rejections - 35 USC § 103

13. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

(a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negated by the manner in which the invention was made.

14. Claims 5, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18,19 are rejected under 35 U.S.C. 103(a) as being unpatentable over Pub No.: US 2001/0013629 to Bai, in view of U.S Patent 4,464,701 to Roberts et al.

Regarding to claims 5, Bai does not teach combining comprises providing conditions effective for the hafnium of the metal layer to chemically reduce the silicon dioxide layer. But Roberts reference teaches the combining comprises providing conditions effective for the hafnium of the metal layer to chemically reduce the silicon dioxide layer, column 3 lines 30-45. At the time of the invention, it would have been obvious to combine the teaching of Roberts's method with Bai's method, because it would have achieved a thinner and substantially higher dielectric constant and breakdown voltage, column 3 line 40-45.

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Regarding to claim 9-11, 16, 17, Bai does not teach forming the hafnium-containing and lanthanum-containing layer comprises physical vapor deposition (PVD), where PVD comprises ion bombardment energy of about 10 electron volts (eV) or less, and heating to a temperature from about 200°C to about 400°C during the ion bombardment. But, Roberts reference discloses the oxidized temperature of 600°C or higher, claim 6. However, such ion bombardment (PVD) and conditions are well known in the art. Also, it would have been obvious to use the temperature of Roberts's method in the range as claimed, because it has been held that where the general conditions of the claims are disclosed in the prior art, it is inventive to discover the optimum or workable range by routine experimentation. See *In re Aller*, 220 F.2d 454, 105 USPQ 233, 235 (CCPA 1955).

Regarding to claim 13, Bai discloses forming the hafnium-containing dielectric layer 130 comprises depositing hafnium to a thickness less than or equal to about 5 nanometer (nm), see table 1. However, the reference does not disclose the forming of lanthanum-containing dielectric layer, claim 7, to a thickness less than or equal to about 5 nm. It would have been obvious to form the lanthanum-containing dielectric layer to a thickness of equal or less than to about 5nm to act effectively as a barrier layer, paragraph [0027].

Regarding to claim 14-15, 18, Bai's reference does not disclose the ratio of the hafnium thickness to the lanthanum thickness of about 1 to 3 to about 1 to 4, and forming the metal containing dielectric layer and the second metal-containing dielectric layer comprises forming the layer to have respective thickness having a ratio of from about 4:1

to about 1:4. However, Bai's reference teach different thickness ratio between first and second metal-containing dielectric layer, paragraph [0020-0024] and table 1.

Accordingly, it would have been obvious to use the teaching ratio of Bai's method in the range as claimed, because it has been held that where the general conditions of the claims are disclosed in the prior art, it is inventive to discover the optimum or workable range by routine experimentation. See *In re Aller*, 220 F.2d 454, 105 USPQ 233, 235 (CCPA 1955).

Regarding to claim 12, it would be obvious the exposing comprises positioning the substrate within the reaction a chamber to oxygen radical within the reaction chamber. Otherwise, the oxidized process would not be occurred.

15. Claims 21, 22, 26, 27, 28, 29 are rejected under 35 U.S.C. 103(a) as being unpatentable over Pub No.: US 2001/0013629 to Bai, and further in view of U.S. Patent 4,464,701 to Roberts et al.

Regarding to claims 21-22, Bai teaches forming of the hafnium-containing dielectric layer comprises first forming a hafnium-containing layer, forming of the lanthanum-containing dielectric layer comprises second forming a lanthanum-containing layer, and wherein the first forming and the second forming encompass chemical vapor deposition (CVD) or other conventional method, paragraph [0017]. However, the reference does not disclose the physical vapor deposition (PVD) comprise electron bean evaporation. But it would have been obvious to use the other conventional method such as PVD comprise electron bean evaporation, because these conventional methods are well known in the art.

Regarding to claim 26-28, Bai teaches the method where the hafnium layer 130 is formed over the layer of silicon dioxide, t_{ox} ; see fig. 1 and claim 4. However, Bai does not teach the heating the dielectric layers to a temperature from about 200°C and 400°C, further comprising providing conditions effective for the hafnium-containing layer chemically reduce the layer of silicon dioxide, and providing the ion bombardment of the hafnium-containing layer and the lanthanum-containing layer using an ion bombardment energy of about 10eV or less. But, Roberts reference discloses the oxidized temperature of 600°C or higher, further comprising providing conditions effective for the hafnium-containing layer to chemically reduce the layer of silicon dioxide, column 3, line 30-45. However, such ion bombardment and conditions are well known in the art as discussed in the above claims 21-22. Also, it would have been obvious to use the temperature of Roberts's method in the range as claimed, because it has been held that where the general conditions of the claims are disclosed in the prior art, it is inventive to discover the optimum or workable range by routine experimentation. See *In re Aller*, 220 F.2d 454, 105 USPQ 233, 235 (CCPA 1955).

Conclusion

16. Any inquiry concerning this communication or earlier communication from examiner should be directed to Thao Le whose telephone number is (703) 306-0208. The examiner can normally be reached on Monday through Friday from 8:00am to 4:30 pm. If attempts to reach the examiner are unsuccessful, the examiner's supervisor, Mr. Olik Chaudhuri, can be reached at (703) 306-2794. The fax number for this group is (703) 308-7722.

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17. Any inquiry of a general nature or relating to the status of this application or proceeding should be directed to the Group receptionist whose telephone number is (703) 308-0956.

Thao X. Le

20 Feb. 2002



PHAT X. CAO
PRINCIPAL EXAMINER